

REVIEW
OF
TWO SERIES OF AMPHIBIANS*

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(Color plates from drawings by the author.)

INTRODUCTION.

The species described in these articles belong to the Class Amphibia and the living members can be roughly defined as Vertebrates which undergo an external metamorphosis, hatching from eggs (spawn) as tadpoles or larvae, and gradually assuming the adult form. These larvae have gills at some stage of their development and several species complete the metamorphosis inside the egg and emerge as gillless and tailless frogs.

Most amphibians lose these larval gills, except some of the salamanders, like *Necturus* and *Proteus*, after attaining the adult form. Several of the American land salamanders of the genus *Amblystoma* retain the gills throughout life, if the conditions for developing into the land form are unfavorable, and have been known to breed in this semi-larval state.

The members of the *Amphibia* are divided into three Orders, as follows:

The *Apoda* or limbless amphibians, have a vertebral column with rudimentary ribs and amphicoelous vertebrae sometimes to the number of 300. Each vertebra is cupped before and behind and articulated with the adjoining member by means of a cartilaginous plate. Only one lung is present. The shape of these animals is cylindrical, the head is not distinct from the body, there is no tail and the anus is placed at the posterior end of the body. The body shows no internal rudiments of limbs, is naked and ringed by furrows running around it similar to the segments of an earthworm. A few species have calcareous de-

*The specimens described in these reviews have been preserved and donated to the American Museum of Natural History. Marked with all possible data, they are now available for study.

posits in the form of bony scales under the skin. The eye is small, the mouth usually wide, and the teeth large. These animals lead a subterranean life, burrowing in the soil of tropical and subtropical countries. The larvae live in the water until the absorption of the gills. The eggs are round or oval, and are joined together by a gelatinous string. This Order embraces fifty species.

The next order is the *Caudata* or tailed amphibians. These creatures have a spinal column formed of from thirty-seven to ninety-eight vertebrae, which are amphicoelous or opisthocelous, that is cupped in front and behind or only behind. The skin is naked, the head broad, flat and distinct from the body. All *Caudata* have limbs, although some species only rudimentary ones (*Amphiuma*). Sternal apparatus as well as pelvis always present, although the latter is sometimes rudimentary (*Siren*). All members of this order have a tail throughout life. Lungs are usually present, although the *Plethodontinae* have no lungs; breathing solely through their slimy skin. All salamanders or tailed amphibians hatch from eggs and undergo a metamorphosis from larval to adult form. All of the known species, which number about one hundred and fifty, breathe through gills at some period of their existence.

The last order, *Salientia*, or tailless amphibians, is the one to which all species treated in these articles belong. They are characterized by their form and the presence of four well developed limbs. With all the tail is absent in the adult form.

The skeleton is simple, with comparatively a large and broad skull and a short spinal column, consisting of from five to nine vertebrae and which terminates posteriorly in an elongate pelvis. This peculiar pelvic arrangement is necessary for the attachment of certain muscles that are used in leaping or acting as springs in giving impetus to the enormous leaps, which are possible by most members of this order. Short ribs are present only in one family, (*Discoglossidae*). The limbs are always four in number with four digits on the hand and five on the foot, but in a few species some of the digits are rudimentary or absent (*Stumpffia*). Some tree-toads have a rudiment of a fifth finger on the hand. The skin is either smooth or dry, and more or less

granular or warty, but always naked. In a few species (*Mantophryne*, *Ceratophrys*) there are calcareous deposits in the skin in the shape of bony plates or granules. The eye is usually large, bright and so very mobile that it can be lowered into the skull until even with the top of the head.

The life habits of frogs and toads present considerable variation. Some species are terrestrial, some arboreal, some aquatic and others subterranean. The food consists of living insects chiefly, but some of the larger species are cannibalistic, and a few of the largest will eat small mammals, birds and snakes.

The order consists of nine families, divided into eleven sub-families numbering about 1,200 species.

In the descriptions to follow it should be particularly noted that the color patterns are described from *living* subjects throughout. The greater number of the past descriptions of the rarer amphibians are from preserved specimens, and some confusion has resulted owing to the rapid fading of these animals, with a consequent marked change, not only in hue but in *pattern*. The greater number of the colored figures are for the first time sketched from life.

FROGS AND TOADS FROM COSTA RICA.

On May 20, 1914, Mr. Lee S. Crandall, Assistant Curator of Birds at the Zoological Park, and Donald Carter, a student at the Park, returned from a six weeks' collecting trip in Costa Rica. The trip resulted in the capture of many interesting birds and other animals, among the latter being ten species of frogs, toads and tree toads; most of them never before exhibited in this country. Following is a list of the species:

Family BUFONIDAE—Toads.

Marine Toad, *Bufo marinus*, Seba.

Family HYLIDAE—Tree Toads.

Baudin's Tree Toad, *Smilisca baudini*, Dum. & Bibr.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.

Underwood's Toad, *Hylodes underwoodi*, Blgr.Barred Piping Toad, *Hylodes polyptychus*, Cope.Brown Piping Toad, *Hylodes rhodops*, Cope.

Family RANIDAE—Frogs.

Subfamily RANINAE—True Frogs.

Large-eyed Frog, *Rana chrysoprasina*, Cope.Godman's Frog, *Rana godmani*, Gthr.

Subfamily DENDROBATINAE—Harlequin Frogs.

Blue-legged Frog, *Dendrobates typographus*, Keferst.Scarlet Frog, *Dendrobates typographus ignitus*, Cope.Ornate Frog, *Dendrobates tinctorius*, Schneider.

Family BUFONIDAE—Toads.

The toads of this family have no teeth in either jaw, the shoulder girdle is arciferous or dilatible, and the vertebrae are procoelous, or cupped in front and without ribs. The tips of the fingers and toes are either obtuse, (genera *Notaden*, *Pseudophryne*, *Nectes*, *Bufo*), pointed, (*Myobatrachus*, *Rhinophrynus*, *Cophophryne*) or triangular, and carrying medium-sized or large adhesive disks or pads, (*Engystomops* and *Nectophryne*). The *Bufo*idae are distributed over all parts of the globe except, of course, the Arctic and Antarctic regions, which have no amphibians. Central America and northern South America have the most genera, as well as the greatest number of species. The species number about one hundred and fifty, grouped in nine genera. Of these genera, *Notaden* (one species) and *Myobatrachus* (one species) are Australian, *Pseudophryne* (four species) is Australian and African, *Nectophryne* (seven species) is African and Indian, *Nectes* (four species) Javan and Sumatran, *Cophophryne* (one species) Indian, *Engystomops* (three species) Central—and South American, *Rhinophrynus* (one species) is Mexican and *Bufo* (about one hundred and thirty species), cosmopolitan with the exception of Madagascar, New Guinea and the Australian region.

The habits of this family are terrestrial except the genus *Nectes*, which is aquatic and has enormous webs on the hind feet. *Nectophryne* is more or less arboreal as indicated by the enormously dilated and padded fingers and toes.

Most of the *Bufo* are excellent burrowers, hiding by day and coming forth at dusk to hunt insect prey. Few species, however, are strictly nocturnal, some of the genus *Bufo* (*Bufo fowleri* *B. calamita* *B. quercicus*) having been observed hunting in the brightest sunshine. The genera *Rhinophryne* of Mexico and *Notaden* and *Myobatrachus* of Australia, are almost exclusively termite and ant-eaters, herein approaching most of the species of the family *Engystomatidae* (the narrow-mouth frogs) whom they also resemble in external appearance, small head, enormously fat body, short arms and legs and comparatively smooth skin.

In their movements the *Bufo* are not as agile as the true frogs (*Ranidae*), usually proceeding by short hops, walking, crawling or in rare cases running. They are excellent climbers, taking advantage of every unevenness to obtain a hold, and maintaining their balance in most trying situations. With this they combine great persistence, especially when trying to escape from some pit, well or terrarium. They are but indifferent swimmers and divers with the exception of the genus *Nectes*, and will only enter the water to soak their skin, and during the breeding season for the purpose of depositing their spawn.

All species that have come under observation are great feeders, eating untold numbers of insects, most of which are injurious to plant life. In this they take the place of the insectivorous birds on the ground at night and therefore merit our protection, which unfortunately has been withheld to a great extent until lately. This was probably due to ignorance of their habits, and also to the often unprepossessing appearance of these harmless creatures. The flesh of the larger species is said to be quite as edible as that of some of the true frogs, but is eaten only by a few aboriginal tribes of tropical countries.

In appearance most of the *Bufo* are squat, fat and warty. There are, however, some smooth skinned, long legged tropical species that remind one of a true frog.

Marine Toad, *Bufo marinus*, Seba. (*Bufo aqua*, Latr., *Bufo ictericus*, Spix., *Bufo horridus*, Daud.) (Boulenger, Cat. Batr. Sal. P. 315).

Color: Brownish or greenish-olive, yellowish or reddish-brown or plain dark brown above with or without large, black, insuliform spots, these usually edged with pale yellow. Sometimes a light median line from behind the head to above the vent. There may be a few scattered whitish spots on the back and sides. Arms and legs sometimes distinctly banded with dark brown. The cranial crests, parotoids and larger warts are usually light, reddish brown. Below this toad is dirty white or yellow with or without brown spots.

Structure: The head is broad and crowned with very prominent bony crests diverging from above the nostrils, edging the canthus rostralis, curving around the orbit above, and sending out and down a branch before and behind the eye, several more or less distinct branches towards the median line above, and one connecting with the enormous parotoid glands. These glands curve down over the arms, and in a toad six and a half inches from snout to vent, attain a length of one and three-quarter inches and a width of one and three-eighth inches. They are studded with large pores. There is a distinct bony ridge along the upper jaw on the edge of the mouth. The tympanum is about one-half the diameter of the eye, and very distinct. The body is covered with large round warts. The skin is loose and much wrinkled and creased. Arms and legs are long and powerful, hands and feet large. The ends of fingers and toes are tipped with dark brown. The toes are moderately webbed. Metatarsal tubercle moderately developed.

Size: Adults range from five inches to eight and one-half inches in length from snout to vent.

Range: Southern Mexico through Central and South America to Southern Argentina. Many of the West Indian Islands.

Thirty-one specimens of the giant marine toad, of all sizes from two to seven inches in length were collected. These large toads are very common throughout their range and no doubt are beneficial in helping to keep the insect life of those regions



FIG. 3. MARINE TOAD, *BUFO MARINUS*, SEBA

within reasonable bounds. This is the largest species of the true toads, only exceeded in size by *Rana goliath* and *Rana adspersa*, both African frogs, and possibly *Ceratophrys dorsata* of Brazil. The male can be distinguished from the female by the horny pads on the inner fingers, and by a blackish area on the throat indicating the presence of a large gular pouch. This dark area may be sprinkled with lemon-yellow, especially in young males. The writer has often observed the males sitting with this pouch partly distended in the pan of water provided for their soaking bath in the spacious cage in the lobby of the Reptile House, especially after they had fed well, but so far has not heard their call. The warts on the upper surface of the males are covered with small horny spines, making these toads exceedingly rough to the touch, in contrast to the females, whose warts are round and smooth. When picked up, the male of this species gives voice to a series of harsh squawks similar to those produced by some toy animals. The female is silent, and when handled will shake the whole body as if in a rage, then puff it up enormously but deflating it after a little while with a loud hiss. From the enormous parotoid glands, Dr. J. J. Abel, of Johns-Hopkins University in Baltimore, has recently extracted two distinct and powerful poisons, called respectively *Epinephryn* and *Bufagin*. The latter poison, Dr. Abel has found by experimenting, has many times the strength of *Digitalin*, the "fox-glove" poison, and like this, it affects the heart action. This species has proven one of the hardiest in captivity, seemingly being immune to the festering and bleeding ulcers with which captive toads so often are infested, and to which the majority of them succumb. In the Reptile House these toads are fed on all kinds of insects, and also large earth worms and cockroaches. A few of the largest toads sometimes get an extra tid-bit, such as very young mice or rats.

Although the giant among toads and able to swallow the largest of insects and worms as well as small mammals, this species is not cannibalistic. The writer had repeatedly tried to induce them to eat very young common toads and frogs, which they will snap up but reject immediately. In spite of their enormous size and bulky appearance, the "marine toads" are remarkably agile and quick on their feet. When insects are thrown

into their cage they instantly become alert and with a series of rapid hops, almost cat-like in their stealth, come forth from the darkest corner of their cage where they usually spend the day piled on top of one another and sleeping. Some specimens eventually become so tame that they will take insects and worms from one's hand. The tongue of this toad is very flexible, seemingly more so than in other species. The writer has seen some of the larger specimens snap up a grasshopper or mealworm fully four inches from the toad's head. The species breeds during the rainy season, the eggs being quite small and laid in two strings very similar to those of our own common toads, in puddles, ditches, ponds and canals. The matamorphosis is comparatively rapid, and the baby toads are tiny, measuring scarcely three-eighths of an inch from snout to vent. The call of the male is said to resemble the barking of a dog.

Family HYLIDAE—Tree Toads.

This family is divided into two subfamilies, the *Amphignathodontinae* and the *Hylinae*. It is the latter subfamily only, that we have to deal with in this article. The *Hylinae* or Tree Toads are characterized by the dilatible shoulder girdle, the presence of teeth in the upper jaw, vertebrae cupped in front, absence of ribs, and dilated transverse processes of the sacral vertebra. The end-phalanges of the fingers and toes are claw-shaped and support more or less prominent, adhesive disks. These disks secrete a sticky fluid which, aided by the moist and granular surface of the belly, enable the tree-toads to climb trees, vines and even the glass sides of a terrarium with perfect ease. The skin of the *Hylinae* is always moist and slimy, thus enabling them by means of increased evaporation to withstand greater heat than other amphibians. Tree-toads often can be seen sitting for hours in the most glaring sunlight.

Their skin may be quite smooth or covered with warts of various sizes. In some species of the genera *Hyla*, *Nototrema*, *Nictymantis* and all those of *Pternohyla*, *Corythomantis*, *Trip-rion* and *Tetraprion*, the skin of the head adheres to the skull. The *Hylinae* includes some of the brightest colored and most

attractive of all the frogs and toads. All of the species have great powers of color-change. Some of them are really marvellous in this respect. This applies especially to the genus *Hyla*. Most of the *Hylinae* live on the trees, vines, shrubs and other plants, but a few, however, have such tiny adhesive disks that they are of little use, compelling the creatures to live on the ground. All species are insectivorous, although many of the larger ones incline to cannibalism. The family *Hylidae* contains sixteen genera; one of these, *Amphignathodon*, belongs to a separate subfamily. With the latter there are teeth in both jaws. It includes but one species, *A. guentheri*, of Ecuador, and is exceedingly rare.

The other fifteen genera are included in the subfamily *Hylinae*. There are about two hundred and forty known species of which the genus *Hyla* alone has about one hundred and eighty. The pupil of the eye of the toads of this genus is horizontal elliptic. The toes are webbed. Adhesive disks distinct, sometimes very large. The distribution of the *Hylidae* is as follows: The genus *Hyla* is almost cosmopolitan with over thirty species in Australia and Australasia, about one hundred and thirty-five species in Mexico, Central and South America, seven species in the West Indies, ten species in North America, and one species in Europe and Asia. This latter, *Hyla arborea*, has two subspecies in China and Japan. Of the other genera, *Acris*, (one species, two subspecies) and *Chorophilus* (five species) are North American, *Smilisca* (one species) ranges from Texas through Mexico into Northern South America, and the genera *Nototrema* (eight species), *Hylella* (seven species), *Thoropa* (one species), *Phyllomedusa* (fourteen species), *Agalychnis* (four species), *Nietymantis* (two species), *Tripurion* (two species), *Tetrapurion* (one species), *Diaglena* (one species), *Corythomantis* (one species), and *Pternohyla* (one species) are Central and South American.

This distribution seems to show that the original home of the *Hylidae* was South America. One species of the otherwise North American genus *Chorophilus* occurs in the mountains of Peru (*Ch. cuzcanus*). Quite a number of species of this interesting family are remarkable in their breeding habits. They

do not lay their eggs in ponds, ditches, lakes or swamps as is the habit of most frogs and toads, but use the axillae of large broad-leaved parasitic or other plants for this purpose. One species, *Hyla resinifictrix*, of Brazil, uses knot holes which it lines with the resinous sap of an aromatic tree (*Protium heptaphyllum*) and which soon become filled with rain water. The gigantic *Hyla faber*, also of Brazil, constructs nests or nurseries of mud, forming circular inclosures about twelve inches in diameter in shallow parts of ponds. The eggs are deposited and the tadpoles reared in these nurseries. Other species, (*Hyla goeldi*) and species of the genus *Nototrema* carry the spawn in a pouch on the back until the tadpoles hatch. This pouch is formed by the introverted skin of the back and is possessed by the female only. Species of the genus *Hyla* have the strongest voices of any of the *Salientia*. The call may be a shrill pipe, whistle, a very loud rattle, croak or bark, or a bell-like note (*Hyla gratiosa*, of Florida, *H. faber*, of Brazil) that can be heard in some cases for more than a mile. Each species has its distinctive call and the din produced by these and other toads and frogs in tropical forests during the breeding seasons is said to be ear-splitting.

Baudin's Tree Toad, *Smilisca baudini*, *Hyla baudini*
Dum. & Bibr. (Boulenger Cat. Batr. Sal. P. 371).

Color: The body color is green of varying shades from dark olive through bright pea-green to pale, golden green. A dark band from the eye to the shoulder, covering the tympanum and sometimes extending to the groin, a light spot beneath the eye, and a dark band curving over the upper arm at its insertion. The groin of both sexes is bright yellow, also the throat of the male. Undersides white. These marks are always present. Markings which sometimes disappear with the assumption of pale shades are, a broad band on the middle of the back with two branches extending on the eyelids, two or three cross bars on arms and legs and a few smaller dark spots on the back.

Structure: The head is broad and flat, canthus rostralis acute, eyes large, reddish golden in color and very far apart. The skin is smooth or very finely granular. The legs long, toes

two-thirds webbed, fingers slightly webbed, with adhesive disks smaller than the tympanum. The latter two-thirds the diameter of the eye. The vomerine teeth are situated slightly behind the internal nares, and arranged in a straight series which is interrupted in the middle, thus separating the genus *Smilisca* from *Hyla*. The male has two large gular pouches, one on each side of the throat.

Size: This species is large for a tree toad, reaching a length of three and a half inches from snout to vent. The male is smaller than the female; two and a half inches being the average size.

Range: From southwestern Texas through Mexico to Panama. Four specimens of this fine tree toad were captured near Guapiles, Costa Rica, by Mr. Crandall and his assistant. They were heard calling at night from a piece of waste ground, and their cry was traced to several old tin cans partially filled with water in which the tree toads were sitting. In their cage in the Reptile House they seem to prefer dark corners, where they sleep during the day, coming forth at night and climbing all over the glass sides of their vivarium. They have not been seen feeding since their arrival, although tempted with all kinds of small live insects.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.

This is a most difficult family to define as it approaches the *Bufo*idae, *Hylidae*, *Pelobatidae*, and *Ranidae* in internal as well as in external identification characteristics. Its distribution is South American and Australian almost exclusively. One species (*Liopelma hochstetteri*, the only amphibian there), being found in New Zealand, where it is rare, and four species entering North America.

The family has the following internal structural characteristics: A dilatable shoulder girdle, teeth in the upper jaw only, (subfamily *Cystignathinae*), in both jaws (*Hemiphractinae*), or no teeth at all (*Dendrophryniscinae*). The terminal phalanges or finger and toe ends are never claw-shaped, although some-

times carrying adhesive disks as in the *Hylidae*. The family is composed of three subfamilies, the *Hemiphractinae*, helmet-heads, so called from the shape of their enormous heads which carry large bony protuberances reminding one of the casques or helmets of ancient knights, the *Cystignathinae*, arch-jawed toads, including the greatest number of species, and so called from the enlargement of the lower jaw of some species, and finally the *Dendrophryniscinae*, toads without teeth.

The genera are so numerous and so poorly defined that almost every author gives a different number of the same (Cope, thirty-seven genera, Gadow thirty-two genera, Werner thirty genera, etc.). There are about two hundred and fifty species, of which Australia has about thirty and the remainder are from South America.

Their habits are very diversified, some being burrowers, some strictly aquatic and a great number of species are arboreal, living like tree toads (*Hylidae*) and resembling them in appearance.

Most of the Australian species have a vertical pupil, indicating nocturnal habits.

In size the *Cystignathidae* range from the enormous *Ceratophrys dorsata*, measuring nine inches from snout to vent, and *Leptodactylus pentadactyles*, six to eight inches from snout to vent, to the small *Pseudis minuta*, which measures only three-quarters of an inch from snout to vent. Both extremes in size are found in tropical America. In South America, Central America, Mexico and the West Indies the tree-living species predominate, whereas in Australia the members of this family without exception are burrowers. The largest genus is *Hylodes*, having more than eighty species, *Leptodactylus* has about thirty-five, *Paludicola* has thirty-two and *Ceratophrys* has seventeen species. The other genera have from one to twelve species each.

The breeding habits of this family vary considerably. Some species like *Hylodes martinicensis* carry the tadpoles on their backs while others like some of the *Hylidae* lay the eggs in foamy masses in the axillae of large-leaved plants; but the breeding operations of the majority of the species are unknown. The

tadpoles of two species grow to an enormous size; that of *Calypotocephalus gayi*, a giant water frog of Chile, reaches six inches, the adult frog is six to seven inches from snout to vent, while the tadpole of *Pseudis paradoxa*, also a water frog of the Guianas, is larger still, one specimen being ten and one-third inches long, three and one-third inches of this total is taken up by the body and head, and the tail, which is thick and muscular, measures almost four inches in width by six and two-third inches in length. The size of the larva is all the more remarkable since the adult frog measures only two to two and a half inches from snout to vent.

Underwood's Toad, *Hylodes underwoodi*, Boulenger (Guenther, Biologica Centr. Am.).

Color: The general color is sepia-brown with a W-shaped mark on the shoulders. This mark may be much darker than the ground color or very pale, yellowish brown. The rest of the back is marbled with dark brown, and the arms and legs of some specimens are banded with dark brown. Undersides bluish white, specked with brown.

Structure: The head is long and the snout pointed. The eyes are large with the interorbital space smaller than the eyelid and the skin is rough with large elongated warts, giving this frog some resemblance to our cricket frog. The fingers and toes are free, subarticular tubercles prominent, and the adhesive disks minute, scarcely produced.

Size: From snout to vent the length is one to one and one-quarter inches. The specimens collected were immature and from one-quarter inch to three-quarter inches in length from snout to vent.

Range: Known only from Costa Rica.

Barred Piping Toad, *Hylodes polyptychus*, Cope (Guenther, Biolog. Centr. Am.).

Color: The general color is a dark, brownish olive with a white band between the eyes. The arms and legs are indistinctly

barred, with a rich pink spot on the groin which is hidden when the frog is at rest.

Structure: The skin is finely granulated. The head is broad with the interorbital space equal to or larger than the diameter of the eye. Tympanum small and distinct. Subarticular tubercles distinct. Disks on fingers and toes small, but distinct. Toes not webbed.

Size: The single specimen examined was one and a quarter inches from snout to vent.

Range: Costa Rica.

Brown Piping Toad, *Hylodes rhodopis*, Cope, (Cope Proc. Acad. Phil. 1866).

Color: Brown prevails above, while below it is bluish white with a few scattered brown dots. There is a pale area in front of the eyes on top of the head and the canthus rostralis is margined with dark brown.

Structure: The head is long and pointed and the canthus rostralis acute. The nostrils are close to the top of the snout, the interorbital space is wider than the eye and the tympanum distinct and smaller than the eye. The fingers and toes are equipped with small disks. Subarticular tubercles distinct. The back has several longitudinal rows of warts arranged in the shape of a lyre.

Size: One specimen one and a quarter inches from snout to vent was examined.

Range: Mexico to Costa Rica.

All these small frogs were shy and delicate and did not live long.

Family RANIDAE—Frogs.

The *Ranidae* belong to the second group of tailless amphibians, the *Firmisternia*, so-called because the halves of the shoulder girdle are united below, forming a firm median bar or *metasternum*, instead of overlapping as in the *Arcifera*, to which

all previously described frogs and toads belong. The vertebrae are cupped in front.

The *Ranidae* are divided into the following subfamilies according to the arrangements or absence of teeth:

Subfamily *Ceratobatrachinae*, having teeth in both jaws and consisting of only one genus and species, *Ceratobatrachus guentheri*, of the Solomon Islands. This is a large, huge-headed land frog with horn-like appendages on the eyelids, snout, sides of body and limbs.

Subfamily *Raninae* or true frogs with teeth in the upper jaw only. This is the most numerous branch of the family, comprising about forty genera with some three hundred and seventy species. These are so diverse in identification characteristics and habits that it would be impossible to describe all the genera in this paper, and but a few examples will be mentioned here.

Genus *Polypedatus* (*Rhacophorus*), frogs resembling tree toads in having the tips of the fingers and toes with adhesive disks, but the end phalanges not claw-shaped as in the *Hylidae*. Some species of this large genus have enormous webs between the fingers as well as the toes. They have been called flying frogs but do not actually fly, only jumping from great heights occasionally and using the large expanse of web as a parachute. Fifty-four species are known from southern and eastern Asia, and sixteen from Madagascar. Many species of this genus lay their eggs between leaves glued together by the female to form a sort of funnel which they suspend over a ditch, pond or brook, so that when the tadpoles have hatched they will drop into the water below their nest. This queer mode of depositing eggs is also practiced by the African genus *Chiromantis*, which resembles *Polypedates*, except that it has no web between the fingers and that the two inner fingers are opposed to the outer ones, enabling these frogs to grasp twigs and stems in climbing. Their movements are slow and mechanical, like those of the African and Madagascan cameleons. "Cameleon frogs" would therefore be an appropriate popular name for these queer creatures.

Hylambates with about twenty species, all African, is also a tree frog in the true sense. Our own so-called tree frogs are

really tree toads, being grouped with the toads in the superfamily *Arcifera*.

The genus *Hylambates* has some highly colored frogs with odd and picturesque color patterns. The female of one species (*H. brevirostris*) has been found by Boulenger to have a singular habit of nursing, carrying the eggs about in her mouth. The African and Madagascan genus *Rappia* is also very numerous, having about thirty known species. They are mostly small tree-living frogs with rather short, stout limbs, all beautifully colored and have great powers of color-change.

The female of one species from Madagascar has the singular habit of winding the eggs, which resemble a string of beads, around her forelegs.

Trichobatrachus, only one species of which is known so far, is peculiar in the possession of hair-like papillae forming a thick fringe on each side of the flank, also on the upper side of the thighs. This frog inhabits Central Africa.

Phyllobates, having five species, all small frogs, is a South American genus. The tadpoles of *Ph. trinitatis* of Trinidad, British West Indies, adhere to the back of the male by means of their suckers, and are thus carried from evaporating pools to more permanent ones. *Arthroleptis* comprises twenty species, mostly African. One species, *A. seychellensis*, of the Seychelle Islands, was found on some tree ferns carrying its tadpoles in the same manner as the genus described before, with the exception that the larvae adhered to the back of the adult by means of a sticky secretion.

Rana, the type genus of the whole family, is also the largest, having about one hundred and fifty species, of which fifteen inhabit the United States.

The Indian region including most of the islands of the Indian and Pacific Oceans, has the greater number of species, Africa has but a slightly smaller number.

The structural description of the genus is as follows: The pupil of the eye is horizontal and the tongue deeply notched and free behind. Teeth on the upper jaw and on the vomers, (small

protuberances in the upper jaw), between or slightly behind the internal nares or nostrils. The fingers are free and the toes are more or less webbed. The fourth and fifth metatarsal bones of the central part of the foot diverge, but are united by the web. The terminal phalanges may be simple and pointed or T-shaped, sometimes carrying disks. The external ear plate (tympanum) is usually distinct. The males of most species have vocal sacs, which may be internal (*Rana catesbiana*, *R. sylvatica*, *R. temporaria*), or external, protruding through slits under the angle of the lower jaw or over the arm insertion when they are distended in calling (*R. esculenta*, *R. aesopus*, *R. tigerina*).

Nuptial excrescences in the shape of horny or spiny pads, spikes or granules may be found on the forelimbs and hands of the males of many species, reaching their greatest development in *Rana liebigii* of the Himalayan region, India.

The males of this genus are further distinguished by their heavy forelimbs or arms which in the aforementioned species are enormously developed. Gadow says in his "Amphibia and Reptiles" (Cambr. Nat. Hist.): "All species of *Rana* spawn in the water, except those of the Solomon Islands, where the only permanent bodies of water are roaring mountain torrents unsuitable for the metamorphosis of amphibian larvae."

One species from this group of Islands, *Rana opisthodon*, lays its eggs in moist crevices in rocks near the water. The larvae undergo the whole metamorphosis from tadpole to frog inside the eggs and emerge as perfect frogs, absolutely tailless. The tip of the snout of the young frog is armed with a short, horny protuberance which is used to perforate the egg and is absorbed soon after the animal has emerged. The largest species of all frog-like amphibians is *Rana goliath* of the Cameroons, attaining a length of twelve inches from snout to vent. Next in size are *Rana adspersa* (nine and one-quarter inches), of South and Central Africa, *Rana macrodon* (nine inches) of India and Malaysia, *Rana catesbiana* (six to eight inches) of North America, *Rana tigerina* (six to seven inches) of India and Malaysia, and *Rana guppyi* (six to seven inches) of the Solomon Islands. All these large species are cannibalistic and large examples of our own bull frog have been known to swallow half-

grown rats, small chicks, ducklings, sparrows, toads and young snakes.

Insects, of course, make up the greater percentage of the food.

Some species of this genus are quite terrestrial, only entering the water during the breeding season, while others are typical water frogs never wandering far from their native stream, pool or swamp.

The genus *Gampsosteonyx* resembles an ordinary frog, but has vertical pupils. The terminal points of the fingers end in sharp, bony claws which perforate the skin of the finger tips. One species is known: *G. batesi* from the French Congo.

Subfamily DENDROBATINAE—Harlequin Frogs.

These small frogs are separated from the others of the family by the absence of teeth from both jaws and comprise three genera: *Dendrobates*, of Tropical America, *Mantella*, of Madagascar and *Cardioglossa* with one species *C. gracilis* of the French Congo. The frogs of the genera *Mantella* and *Dendrobates* are very much alike in shape, size and in possession of a striking color pattern. Deep black, bright blues, brilliant reds, greens and yellows in many contrasting combinations are the colors which often form fantastic patterns.

The tiniest insects are the food of these little harlequins of the frogs' world and they are usually found near fallen decaying tree trunks, where they feed on small termites, or in banana plantations, where they can be seen in numbers about the fallen and decaying fruit which attracts myriads of small fruit flies.

Dendrobates has seventeen species, *Mantella* nine species and *Cardioglossa* has one.

Subfamily RANINAE—True Frogs.

Large Eyed Frog, *Rana chrysoprasina*, Cope (Boulenger, Cat. Batr. Sal. P. 49).

Color: The head is green and the back, sides and limbs a yellowish olive with a few brown specks. A dark line extends

from the tip of the snout through the nostril and eye over the tympanum and below the lateral glandular fold to the groin. The edge of the upper jaw has a few small brown spots, the eye is brassy yellow and the sides and belly an immaculate golden yellow.

Structure: The head is broad, flat, snout acuminate, projecting beyond the mouth and the tympanum two-thirds the diameter of the eye, which is very large. The tips of the fingers and toes are slightly dilated, fingers very long and slender, and the toes webbed four-fifths of their length. The skin is very finely pustulated above and smooth underneath. There is a lateral fold on each side of the body and narrow longitudinal glandular ridges on the calf of the leg.

Size: The specimen examined was three and one-quarter inches from snout to vent.

Range: Costa Rica.

One adult, one young frog and several tadpoles of this beautiful species were collected near Guapiles. This frog is very shy, as most large-eyed frogs usually are, and seeks cover with great rapidity when disturbed. Like most water frogs it is a good feeder, and so far has proven a very satisfactory captive. When taken up it will sit quietly in the open hand and will not jump unless frightened by a quick movement. Several of the tadpoles have metamorphosed and are living now as young frogs in a vivarium with small tree toads on the main floor of the Reptile House. In the daytime they usually sit concealed under some moss, but come forth with the darkness and occupy the pan of water provided for them.

Godman's Frog, *Rana godmani*, Guenther (Biologia Centr. Am.).

Color: The color is greenish olive above with indistinct darker spots and whitish below.

Structure: The structure is like that of *Rana clamitans*, but with much shorter legs.

Size: One young specimen metamorphosed from a tadpole is in the Reptile House. This frog is just as shy as the preceding species, constantly hiding under a large, flat stone in its terrarium. The size of the adult is from two and one-half to three and one-half inches.

Range: Costa Rica.

Subfamily DENDROBATINAE—Harlequin Frogs.

Blue Legged Frog, *Dendrobates typographus*, Keferstein (Boulenger, Cat. Batr. Sal. P. 143).

Color: This frog is a brilliant red above and below with or without tiny black dots. The legs and forearms are brilliant dark blue or blue-black, and on the upper side of the thighs there is a row of small red dots. The blue of the inner arm extends across the breast.

Structure: The snout is obtuse and the canthus rostralis rounded. The tympanum is distinct but small, measuring about one-half of the diameter of the eye, and the interorbital space twice the width of the eye. The arms and legs are slender and moderately long with disks on the fingers and toes equal to or exceeding the tympanum in size. The skin is smooth and shiny.

Size: Adult frogs are one inch or less from snout to vent.

Range: Costa Rica. Eight of these queer little frogs were collected by Mr. Crandall. They were found prowling along the decaying timbers of a fallen fence, probably hunting for the small white termites that usually infest such places.

Scarlet Frog, *Dendrobates typographus*, subspecies *ignitus*, Cope (Proc. Acad. Phil. 1874).

Color: As the name implies, it is brilliant red all over except for a small star-shaped area on the breast and a larger one at the junction of the hind legs and the belly, beneath which is dark blue.

. *Structure*: Exactly like *D. typographus* var. *typica*.

Range: Costa Rica. Rarer than the typical form. One specimen from Limon.

Ornate Frog, *Dendrobates tinctorius*, Schneider, (Boulenger Cat. Batr. Sal. P. 142).

Color: The color is very variable, the single specimen collected by Mr. Crandall was bright emerald green and black; the green predominating above and the black below.

Structure: The snout is truncate and the canthus rostralis rounded. The interorbital space is wider than the diameter of the eye and the tympanum one-half the diameter of the eye. The arms and legs are slender, with the disks of the fingers and toes distinct. The skin is smooth and shiny. The male has a sub-gular vocal sac.

Size: From snout to vent it is one to one and one-half inches in length.

Range: Tropical America. This specimen has proven the hardiest of the smaller frogs brought from Costa Rica and lives on tiny fruit flies that are enticed into its terrarium with slices of banana, apple or pieces of wet bread. It can see a fly at quite some distance, and with short hops follows every turn of its flight until it alights within reach, when it is greedily snapped up. The tongue, which is not notched behind like that of the frogs of the genus *Rana*, can be thrust out for quite some distance. This curious little creature does not always hop, but will often elevate its body on its long slender legs and stalk around as though walking on stilts. The adhesive disks, although tiny, are large enough to enable this little frog to climb up the glass sides of its terrarium. Owing to their intensely bright coloration, Mr. Ditmars has suggested the very appropriate name of Harlequin Frogs for these odd creatures.

The frogs of the genus *Dendrobates* are known for the intensely virile poison contained in their skin secretion. This poison, especially that of *D. tinctorius*, has been put to several

uses by the aborigines, one being that of an arrow poison, and another a bleaching agent, which turns the green of parrots' feathers to yellow. The poison, like that of the toads, has no power to injure by touch, acting only when injected into the circulation or rubbed into a deep wound. The life habits of these queer little creatures are also worthy of note, especially the nursing or carrying about of the tadpoles. These habits are shared by the frogs of the *Ranoid* genus *Prostherapis* and *Arthroleptis*, and by species of *Hylodes* of the *Cystignathidae*. As has been observed by the naturalists J. Natterer, H. S. Smith and A. Kappler, frogs of this genus will take their tadpoles upon their backs and carry them to another pool in times of drought. A. Kappler saw *D. tinctorius* and *D. trivittatus* in Surinam go into evaporating pools, sit still awhile and then emerge with tadpoles, some frogs carrying from twelve to eighteen, which adhered to their backs by means of a sticky secretion. Whether this secretion is exuded by the frog or the tadpole is not known as yet, nor has the sex of the nurse been determined up to the present writing.

Since the arrival of this collection additional material has been promised us by several gentlemen who have been to the canal zone and who, upon being shown the specimens, said that they were fairly abundant in those regions. Other interesting frogs, toads and tree toads have also been promised us from that region, and it is hoped that the writer will be enabled to make further observations on these interesting and little-known creatures. Much work is yet to be done in this line of investigation, and a large field is open for the student having the opportunity to observe these creatures in their natural environments.



Richard Deckert, pinx

FIG. 4. AUSTRALIAN "FROGS"

Sand "Frog", *Limodynastes dorsalis*, Gray
Perron's Tree Toad, *Hyla perronii*, Bibron

(Two color phases)

FROGS AND TOADS FROM NEW SOUTH WALES.*

The Australian frogs and toads that are described in this paper will be of especial interest, since it is the first time that these important species have been exhibited in the Reptile House (alive) or the United States. Among them are included the following species:

Family BUFONIDAE—Toads.

Australian Toad, *Pseudophryne australis*, Gray.

Family HYLIDAE—Tree Toads.

Perron's Tree Toad, *Hyla perronii*, Bibron.

Golden Tree Toad, *Hyla aurea*, Lesson.

White's Tree Toad, *Hyla coerulea*, White.

Family CYSTIGNATHIDAE—Arch-Jawed Toads.

Sand "Frog," *Limnodynastes dorsalis*, Gray.

Silver "Frog," *Heleioporus pictus*, Peters.

Family BUFONIDAE—Toads.

Australian Toad, *Pseudophryne australis*, Gray. (Bou-lenger Cat. Batr. Sal. P. 277).

Color: Above, the body is blackish brown with a yellow or reddish narrow streak on the posterior back. The posterior sides of the arms are bright orange-yellow and the rear sides of the thighs usually have a few yellow spots. The throat, abdomen and under surface of the arms and legs are marbled black and white.

Structure: The head is rounded; canthus rostralis not produced. The interorbital space is as wide as the eyelid. The fingers and toes are short without web or dilatations. The skin is smooth or with a few indistinct flat warts. With the male there is an internal gular vocal sac, and an oval flat gland on the hinder side of each thigh. The pupil of the eye is horizontal.

*A resumé of the Families embraced in this article will be found in the preceding pages.

Size: One and one-quarter inches, snout to vent.

Range: Australia. The two specimens examined were from near Sydney, N. S. W. This little toad is said to be quite common all over Australia in localities favorable for amphibian life, and is interesting on account of its breeding habits. The large eggs are laid in damp places in numbers up to ninety under stones, stumps and other hiding places, and have been found in November, January and May near Sydney. Oviposition takes place after heavy rains and the next rain is depended upon to set the larvae free.

This may occur within two or three weeks, or three or four months. The embryo is very tenacious of life and, as noted above, will accommodate itself to remaining in the jelly-like mass of the egg for a long time. The actual limit for this has not yet been determined; four months being the longest time recorded. The two specimens now in our collection seem to be hardy, and live in company with *Hyla pickeringii* and *Dendrobates tinctorius* in a small terrarium, the bottom of which is covered with very damp wood-pulp.

They feed greedily on all kinds of small insects; the method of hunting differing from that of any frog or toad observed by the writer. Instead of hopping they slowly and deliberately creep up to their intended prey, moving each arm and leg separately, first an arm, then the leg of the opposite side, then the other arm and lastly the other leg, giving the whole movement a singular mechanical appearance. When about a half-inch from the insect, the tongue shoots forth with lightning-like speed and the insect vanishes. The toad retains its seemingly strained position until another victim is sighted, when the whole manœuvre is repeated. When disturbed, however, these toads hop in ordinary fashion.

Family HYLIDAE—Tree Toads.

Perron's Tree Toad, *Hyla perronii*, Bibron (Boulenger Cat. Batr. Sal. P. 390).

Color: Brown above, but subject to great variation and color-change. There may be a distinct pattern of dark marblings

or dots, but when the animal is at rest, it is usually dark brown, without dark spots, though with bright yellow dots, which are lined with black and intermingled with emerald green spots slightly larger than the head of a pin. The abdomen is white, throat (male) marbled with brown, and the arm-insertion (behind), the groin and the concealed surface of thigh, calf and foot are bright orange, marbled with black. These colors are not seen when the frog is at rest. The eye is silver with the pupil contracted to a tiny square with four black lines radiating from it and dividing the eye into quarters. When active the color fades until the whole frog is pale reddish or yellowish brown and the arms and legs barred with darker brown. The color of the eye also changes, becoming bright yellow as the pupil expands into a regular, horizontal oval.

Structure: The head is broader than long, snout rounded and canthus rostralis rounded. Loreal region slightly concave. Interorbital space equal in width of the diameter of the eye. Tympanum distinct and two-thirds the diameter of the eye. The fingers are half webbed and the toes about three-fourths webbed, with large adhesive disks about half the diameter of the eye. The upper surface is sometimes smooth and occasionally covered with small roundish warts. A fold of skin extends from the eye over the tympanum to the shoulder, and another fold across the breast. The male has a large subgular vocal sac. The entire lower surfaces are granulated.

Size: It attains a length of two and a half inches from snout to vent.

Range: Northern and Eastern Australia and Tasmania.

One specimen from near Sydney, New South Wales, is in the collection of the Reptile House. It usually sits in a corner and near the top of its vivarium, with the pupils contracted, apparently sound asleep. At dusk it becomes active, climbing slowly over the glass sides of the case until it spies an insect, when it is capable of making enormous leaps. It does not seem particularly shy, and will allow itself to be handled, clinging to one's fingers with its sticky toes. When the plants in the Reptile House are being syringed in the morning and evening, the sound of the splashing water stimulates this tree-toad to giving voice to its

loud call. This call resembles the noise of the pneumatic drill used by structural iron workers, and might be described as a loud, metallic rattling. The throat pouch is expanded into a large globe, larger than the tree-toad's head, while the entire body vibrates with the force of the exertion used in producing the call.

Golden Toad, Golden "Frog," *Hyla aurea*, Lesson (Bou-
lenger Cat. Batr. Sal. P. 410).

Color: The general body color is a bright metallic green, sometimes bluish, sometimes yellow in tone. From the tip of the snout through the nostrils, over the eyes and tympanum to the groin, extends a wide brown band, and on the back there are usually a series of spots of varying size and shape, but of the same color, which sometimes fuse into longitudinal bands. A brown band, which becomes yellow or silver, passes from the tip of the snout along the upper margin of the mouth and ends at the shoulder. From the nostril through the eye, interrupted by the tympanum, is a black streak which ends behind the shoulder. The arms and legs are brown, the former spotted, and the latter longitudinally banded with green. All of the brown spots and bars may become beautifully golden or coppery bronze, and the glandular, lateral fold a pale, golden color. The color at the groin is deep blue-black. The sides are green, sometimes with a bronze shading, the tympanum bronze and the under sides pure, silvery white. The entire toad is subject to strong color changes, sometimes becoming plain blue-black with metallic reflections. The eye is large, brilliant and of a beautiful, reddish-gold color.

Structure: In general form it is like a *Rana*. The head is a little longer than broad, the interorbital space narrower than the eyelid, tympanum about half the diameter of the eye, canthus rostralis distinct and the loreal region concave. The fingers are free and the toes almost entirely webbed. The disks of the fingers and toes are small. The skin may be entirely smooth or warty above. A longitudinal fold extends from the eye to the groin. The male has two internal vocal sacs.

Size: It attains a size of two and a half to three and a half inches from snout to vent.



FIG. 5. GOLDEN TREE TOAD, *HYLA AUREA*, LESS.



FIG. 6. WHITE'S TREE TOAD, *HYLA COERULEA*, WHITE